Connecting the Risk Decision Authority Criteria (RDAC) to its Environment

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Objective

- This presentation extends RDAC **architectural analysis** down to embedded computing platforms and up to major programs of record. This presentation ties together:
  - Hardware/Firmware Risk
  - Software Risk
  - Obsolescence Risk
  - Management of these risks via RDAC
  - Risk Management at the Program of Record Level

RDAC: Risk Management Framework

- RDAC: **Risk Decision Authority Criteria**
- Originally created to guide accreditation of CDS solutions in a Secret and Below Initiative (SABI) environment
  - Management of Residual Risk
- Usage has expanded over time to include accreditation of System of Systems solutions
  - **Common Vulnerabilities** found in prior system accreditations
  - **Common Threats** that challenge mission capability
  - **Analysis** that system **architecture** addresses the vulnerabilities and adequately resists the threats

Risk Management

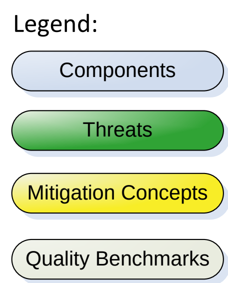
- Impossible technically and financially to counter all known risks
- Mitigate the known risks we can’t counter
- Understand the residual risk after known risks are countered or mitigated
  - Determine if system architecture is sufficiently robust with respect to the residual risk
- What about the risks we don’t know or can’t anticipate?
  - Determine if system architecture is sufficiently robust to withstand additional risks
- *Obsolescence is a significant technical and financial threat not often addressed during original system risk analysis*
  - Obsolescence events typically cost more than the original implementation, certification, and accreditation combined

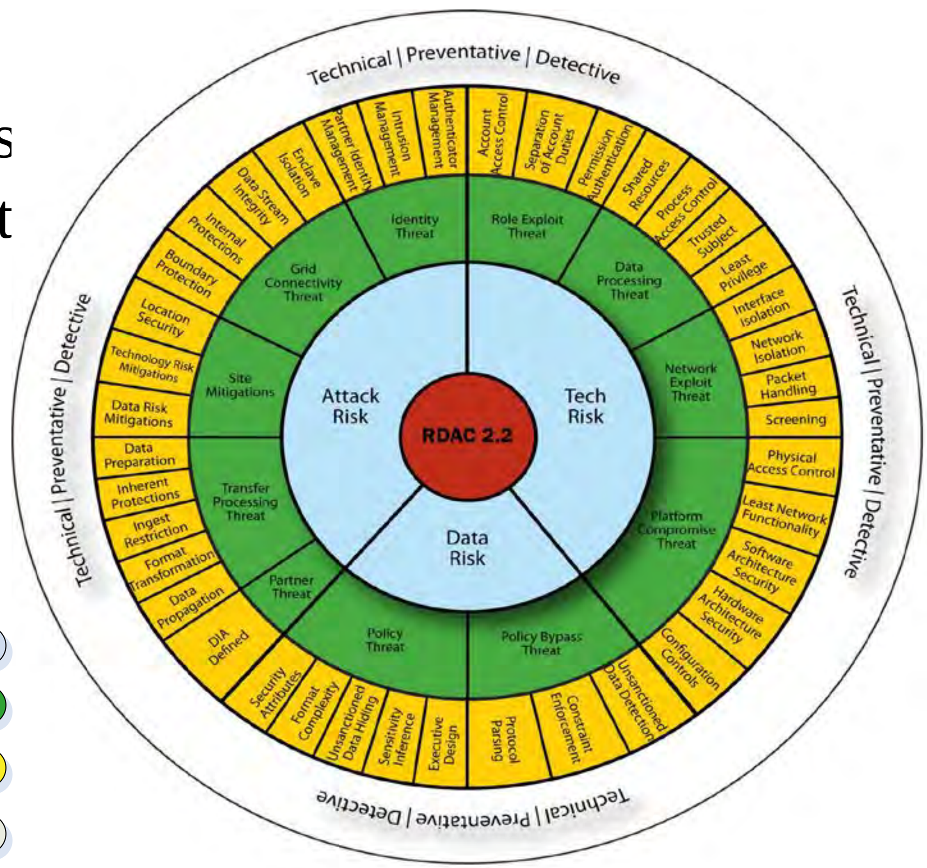
System Life Total Cost of Ownership

- Implementation
- Certification / Accreditation
- Deployment
- **Operations & Maintenance**
- **Technology Refresh**
- **Growing Attack Surface over time**
- **Obsolescence Events**

RDAC Manages Three Kinds of Risks

- Technical Risk
  - Data Processing and Platform Compromise
  - Role and Network Exploit
- Data Risk
  - Security Policy Completenes
  - Security Policy Enforcement
- Attack Risk
  - Identity Threat
  - Connectivity Threats
  - Physical Threats
  - Transfer Threats





Additional Risks to be Managed

- Stronger Adversaries
  - Increased capability of nation-state adversaries
  - Increased capability of sub-national and transnational adversaries
- Increased Attack Surface
  - Larger and more complex systems
  - Everything is connected
    - *Enables world wide remote adversaries*
    - *Mobile personal devices based on commodity software becoming the warfighter's interface of choice*
- Extended System Lifetimes
  - Feature creep complication or invalidating original system security architecture
  - Reuse in unanticipated environments
- ***Yesterday's code was not intended to counter today's threats***

Obsolescence Risk

- COTS hardware platforms become unavailable because of market influences
- COTS software platforms become unavailable for the same reasons
- “Murphy” Obsolescence:
  - Hardware and software do not become obsolete at the same time
  - COTS hardware and software each become obsolete at the worst possible time
  - The version of COTS software that was accredited will not run on any COTS hardware you can still buy
- Murphy was an optimist:
  - Ashton Carter, USD AT&L: “We’re asking you to do more without more.”
    - “And make it network-ready”
    - “And make it Multi-level Secure”
    - “And implement it as a field upgrade”
- ***AND MAKE IT HAPPEN NOW!***

Using RDAC to Manage the Other Risks

- And also mitigate Obsolescence Risk!
- Two pronged approach:
  - Decompose large and complex security policies into small and simple independent components
    - Sufficiently large and/or complex policies may require formal verification (more about this later)
  - Architect systems such that association of data and metadata is incorruptible and verifiable

Managing Development Risk

- Can’t manage development risk without understanding
- Data -> Information -> Knowledge -> Understanding
- Data -> Information (Analysis)
  - Static Analysis of code, data structures, information flow, and requirements
    - Coverity, Code Sonar, Code Surfer, Understand of C++, …
    - University of Kentucky Requirements Analysis Tools
- Information -> Knowledge (Reduction)
  - Consistent interpretation of information and requirements across platforms, analysts, organizations, and decision makers
    - Metadata Tagging (GPS, TOD, Mission Phase, Classification, Release-ability) of all data streams
    - Architectural Analysis Tools and consistent use of Data Dictionary
    - RDAC, Architecture and Requirements Analysis
- Knowledge -> Understanding (Visualization)
  - Mitigation of Risk within Architecture
  - Minimization of total cost of ownership
    - Affordable recovery from zero-day defects and obsolescence events
- **Risk mitigation during development requires continuous review with updated understanding of evolving risks and technology**

Managing Operational Risk

- Can't manage operational risk without understanding
- Data -> Information -> Knowledge -> Understanding
- Data -> Information (Analysis)
  - Consistent interpretation of information across platforms, analysis, organizations, and decision makers
  - Metadata associated with information to give context, classification, and release-ability
- Information -> Knowledge (Reduction)
  - Data and metadata organized so the right questions can be asked
  - Architectural analysis to discover accidental data and control coupling
- Knowledge -> Understanding (Visualization)
  - Actionable assessments
- **Risk mitigation during operation requires continuous monitoring with updated understanding of evolving risks and technology**

Tools Enable Understanding

- Can’t understand risk without tools
  - Commonly exploited vulnerabilities are caused by tangled architectures, lack of standards, and common programming flaws
- Architecture Analysis Tools
  - Visualize and verify compliance with architectural design goals
- Static Analysis Tools
  - Verify correctness and standards compliance of code
- Dynamic Analysis Tools
  - Verify correctness of concurrency models

Decomposition of Large Complex Policies

- Implement the desired policy while simultaneously eliminating possibility of internal inconsistencies
- Provide an infrastructure with three characteristics
  - Integrity of components can’t be compromised
  - Information flow among components is controlled
  - Data is securely associated with its metadata at its source
- Create a flexible policy enforcement framework
  - React quickly to changes in operational requirements
  - Adapt to obsolescence events at reasonable cost

Association of Data and Metadata

- Cross domain guards no longer change the sensitivity of data
  - Redaction rule authors can’t anticipate all use contexts
  - Even perfectly designed and implemented redaction is vulnerable to aggregation
- Cross domain guards become simple information flow reference monitors
  - More resistant to operational risks and obsolescence risks

Planning for Assurance

- Plan for assurance of reference monitors during the entire system life
- Systems evolve with each technical refresh
- Risk management strategy and assessment of that strategy must also evolve in lock-step with the system
- Perform RDAC analysis at each stage of system life to prevent costly security shortcomings later

Example Reference Monitors

1. CDS: movement of data and metadata between domains based on releaseability policy for data and metadata
    a. Data and Metadata Fusion
    b. Data and Metadata Extraction
2. Encryption: data at rest (AT), over the air (IA)
3. Metadata Tagging, binding data to its properties
    a. Mission Phase, GPS, Track, Time/Date
    b. Sensor characteristics
    c. National and classification markings of subject and object
4. Mapping of classification and releaseability markings between nations

Reference Monitor Characteristics: ***NEAT***

- **N**on-bypass-able
  - Information flows only along the paths intended by the system designer and there are no unintended paths
- **E**valuateable
  - Observes Principle of Least Privilege in all aspects
- **A**lways-invoked
  - Policy of Reference Monitor type is correctly enforced each and every time the reference monitor is invoked
- **T**amper-proof
  - Cyber Hard infrastructure and resource management

Infrastructure Characteristics: ***TIME***

- **T**ype safety
  - Sustain service in the face of faults, errors, failures, hostile, and unforeseen use cases
- **I**nfiltration
  - External subjects should NOT have influence over local resources/objects
- **M**ediation
  - Trusted subjects that have access to multiple information flows and/or multiple critical functions should only allow use of the information flow and critical functions by authorized subjects
- **E**xfiltration
  - Internal subjects should NOT have influence over external resources/objects

Non-Iterative Process

- When we try to bolt on security at the end
- **Measures quality of the system only after everyone thinks the job is done**
  - *All the time is gone*
    - (and the system was probably late)
  - *All the money has been spent*
    - (and the system was probably over budget)
- **Obsolescence events may force C&A to start over from the very beginning**

Non-Iterative Process

- Performing RDAC only during original system C&A is reactive
  - Even with requirement analysis traceability tools
    - Requirement satisfaction analysis becomes obsolete over time
  - Even with static analysis tools
    - Fixing *this* often breaks *that*
    - Same code, different platform forced by hardware obsolescence can make original risk analysis irrelevant

Iterative Process

- ***Iteratively* using requirements traceability tools and static analysis tools is proactive**
  - Over time, even innocuous defects become vulnerabilities
  - Ensures continual completeness of the system security solution
  - Ensure continual effectiveness of the solution
  - Discovers voids and defects at the most cost effective time
    - *Prevents "Enhancing this broke that"*
  - Positive effect on total system assurance over the entire system life cycle

Extend RDAC Downward to Embedded System Components

- Embedded component specific system risks
  - Increased hardware complexity (i.e., multi-core)
  - Provenance of COTS firmware
  - OS evolution from bare metal to kernels to RTOS to Linux
  - Increased embedded system scope and complexity
- Applying RDAC to embedded system risks
  - Provenance of active elements
    - Can we trust that integrated memory controller/PCIE Bridge/Network Interface chip?
    - What do we really know about that TCP offload engine?
  - Global hardware and software supply chains
    - Is the original architecture still valid?
    - Have new vulnerabilities been introduced?

Extend RDAC Upward to Programs of Record

- Must consider both operational risk and obsolescence risk
- *Iteratively* performing risk analysis manages obsolescence
    - Reimplementation is implementation at the most expensive stage possible
    - Flexible embedded system frameworks and robust binding of metadata enable adaptation, extension, and interconnection instead of reimplementation

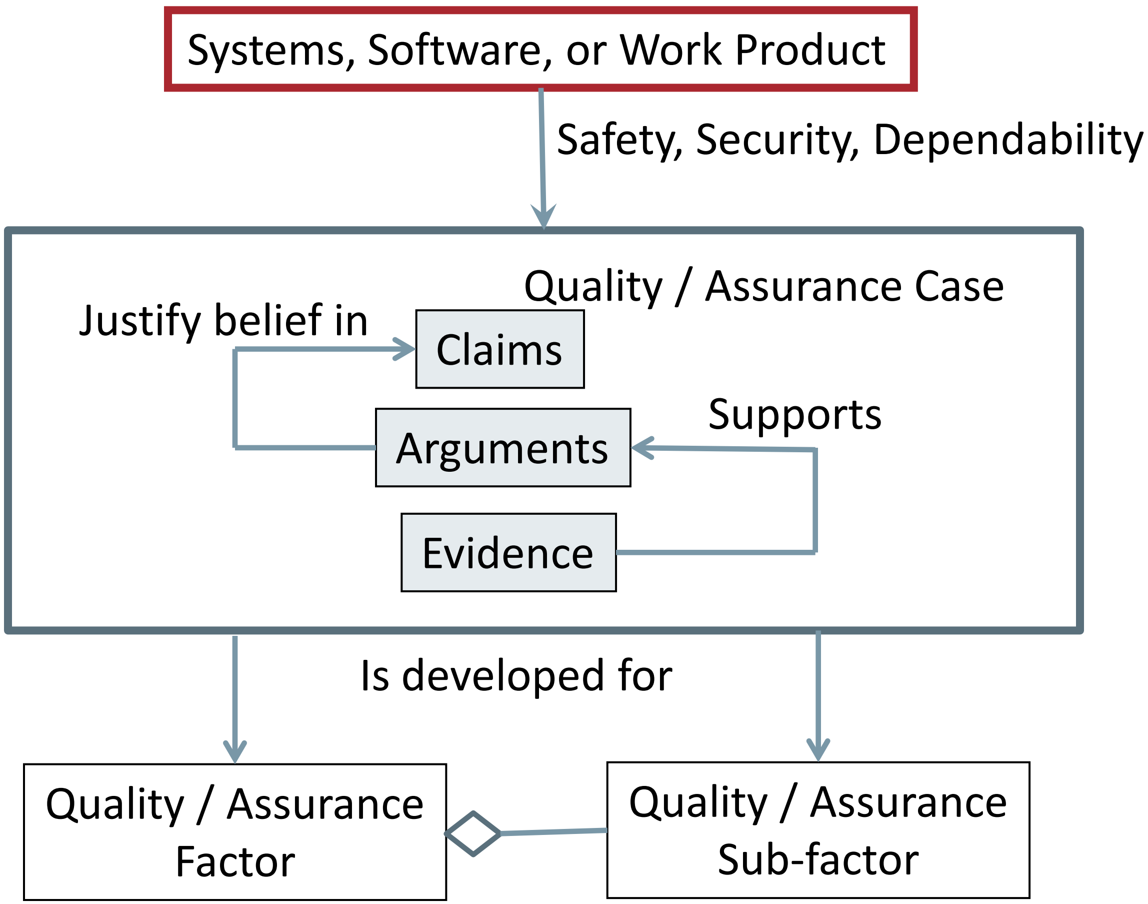
Applying RDAC to Program of Record Risks

- Iterative RDAC process during operation is applicable to all platforms and systems
- RDAC should be adopted as applicable to each platform or system
  - Within capabilities of current management personnel
  - Adoption manages cost and schedule impact of obsolescence events
    - Example: Upgrade of a single line of code can require six aircraft for six months of retesting and can cost up to $6 million

Applying MILS / OSA to RDAC

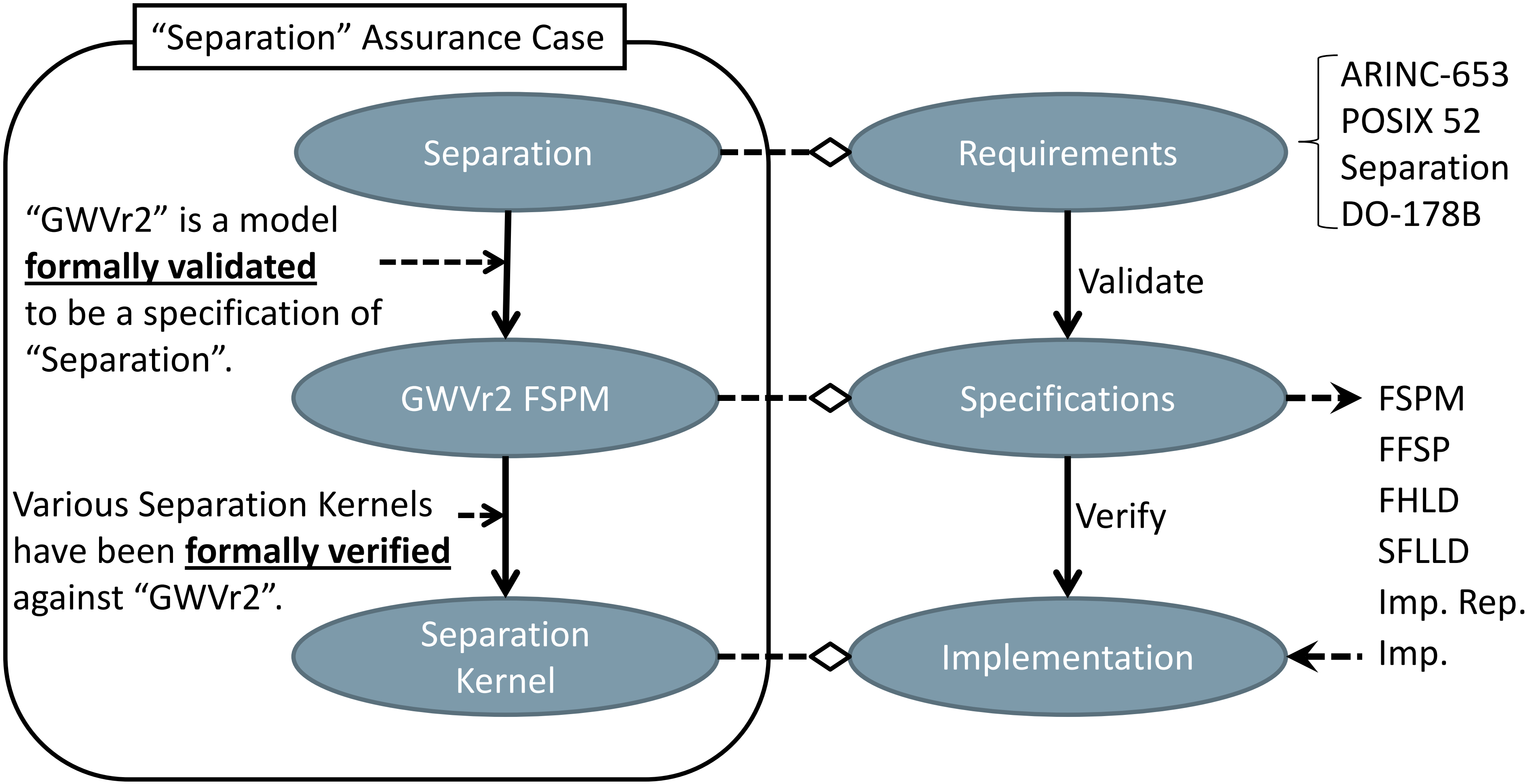
- MILS: Multiple Independent Levels of Security
- OSA: Open System Architecture
- MILS / OSA
  - Leverages separation, damage limitation, periods processing, and controlled information flow
  - Isolates applications from technology and implementations
  - Converts Security Information / Architecture into Security Awareness and Understanding

ISO/IEC/IEEE 15026 Assurance Case



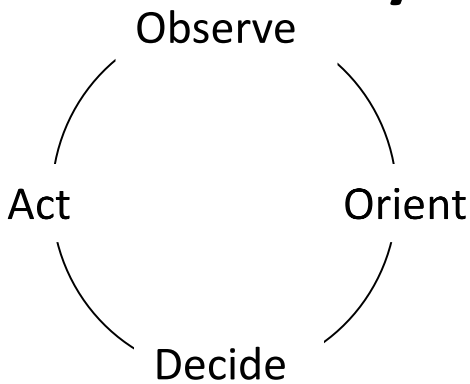
- Attributes
  - Clear, Simple
  - Consistent
  - Complete
  - Comprehensible
  - Defensible
  - Bounded
  - Life Cycle
  - Testable
  - Open Interface
- Dependability
  - Sustain service in the face of faults, errors, failures, hostile, and unforeseen use cases

Formal Validation and Verification of Avionics Systems



"GWVr2" was formally **validated** to provide "Separation" by formally demonstrating that an application level Reference Monitor that is non-bypass-able and tamper-proof can be constructed on an ARINC 653 Separation Kernel. - Proof presented in 2004 ACL2 Workshop.

Survivability



✓**CONFIDENTIALITY**
- Critical Data **PROTECTED**

✓**INTEGRITY**
- Free of Unauthorized Manipulation

✓**AUTHENTICATION**
- Identity Confirmed

✓**AUTHORIZATION**
- Privilege Confirmed
- Mutual Suspicion

(Reduced access based on authentication uncertainty)

✓**NON-REPUDIATION**
- Proof of Data Origin & Delivery

✓**AVAILABILITY**
- Critical functions **READY**

✓**SAFETY**
- Determinism
- Reliability
- Independence

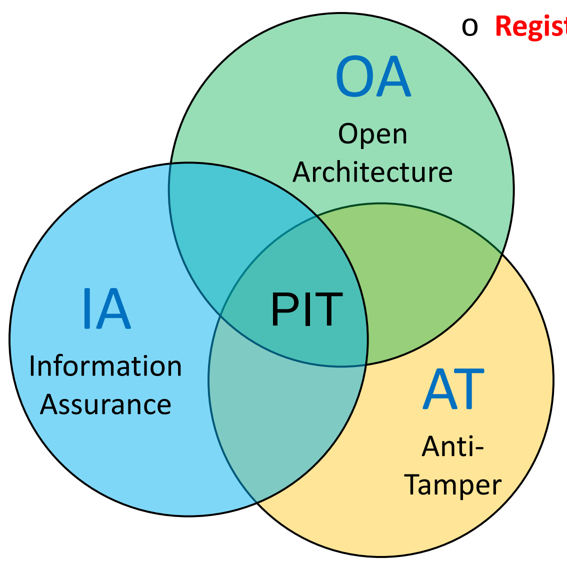
✓**DESIGNATE KEY INFORMATION EXCHANGES**
- **Standardize** similar areas at Enterprise level across Primes
- Blue force tracking, strike, mission planning , weather, …

✓**MODULARITY & VISIABILITY**
- **Design** for change and affordable technology refreshes
- **Minimize** attack surface
- **Design** for recovery and adaptation against Zero-day Defects

✓**RE-USEABLE COMPONENTS**
- Commercial based standards (POSIX, Open GL) - **unmodified**
- Published standards (IEEE 1394, 802.11) - **unmodified**
- Established proprietary standards (USB, Blue Ray) - **unmodified**

✓**INTEROPERABILITY & SECURITY (CJCSI 6212.01E)**
- Global Network Information Enterprise Architecture
- Support for Distributed degree of trust systems

✓**ENABLING ENVIRONMENTS**
- Infrastructure and Enterprise API's **Separable**
- **Decouple** data producers and consumers (cloud computing)
- **Register** data grams and data streams within metadata registry



✓**DETERRENCE**
- Undesirable Consequences
- Strength of Mechanism

✓**PREVENTION**
- Defense in Depth
- Obfuscation

✓**DETECTION**
- Visual, Alarm, Loss of Function, Attestation
- Monitoring

✓**RESPONSE**
- Destruction, Disabling, Zeroization
- Adaption

Web Resources

- Coding Standards and Practices
  - http://www.cert.org/secure-coding/scstandards.html
  - http://cwe.mitre.org/
- National Vulnerability Databases
  - http://web.nvd.nist.gov
  - http://cve.mitre.org/
- DHS Pocket Guides for Security
  - https://buildsecurityin.us-cert.gov/swa/pocket_guide_series.html
- SEI Software Assurance Curriculum
  - http://www.sei.cmu.edu/library/abstracts/reports/10tr005.cfm
- Risk Management Framework
  - http://csrc.nist.gov/publications/nistpubs/800-37-rev1/sp800-37-rev1-final.pdf